WE CLAIM:

1. A rotary module for implementing a pressure swing adsorption process having an operating pressure cycling between an upper pressure and a lower pressure for extracting a first gas fraction and a second gas fraction from a gas mixture including the first and second fractions, the rotary module comprising:

a stator including a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and a plurality of second function compartments opening into the second stator valve surface; and

a rotor rotatably coupled to the stator and including a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second stator valve surface, a plurality of flow paths for receiving adsorbent material therein, each said flow path including a pair of opposite ends, and a plurality of apertures provided in the rotor valve surfaces and in communication with the flow path ends and the function ports for cyclically exposing each said flow path to a plurality of discrete pressure levels between the upper and lower pressures for the pressure swing adsorption process;

a gas mixing means in communication with at least two function ports for mixing a relatively higher pressure gas flow with a relatively lower pressure gas flow to effect a let-down of pressure in the relatively higher pressure gas flow, while providing a source of reduced pressure or vacuum to the relatively lower pressure gas flow.

2. A rotary module for implementing a pressure swing adsorption process having an operating pressure cycling between an upper pressure and a lower pressure for extracting a first gas fraction and a second gas fraction from a gas mixture including the first and second fractions, the rotary module comprising:

a stator including a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and a plurality of second function compartments opening into the second stator valve surface; and

a rotor rotatably coupled to the stator and including a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second stator valve surface, a plurality of flow paths for receiving adsorbent material therein, each said flow path including a pair of opposite ends, and a plurality of apertures provided in the rotor valve surfaces and in communication with the flow path ends and the function ports for cyclically exposing each said flow path to a plurality of discrete intermediate pressure levels intermediate between the upper and lower pressures for releasing gas from or supplying gas to the flow paths so as to perform the pressure swing adsorption process;

gas expander for pressure letdown of gas released from or supplied to a flow path at an intermediate pressure level, and for recovery of mechanical power for rotation of the rotor from the pressure letdown.